present an almost necessary result of the character of the two fields of study that the zoölogist should have the advantage in the study of variation, and the palaeontologist in the study of survival and hence of phylogeny? And that parallel lines of survival should be fostered in different groups by natural selection from fortuitous variation need not surprise us.

This objection may not apply to inferences drawn from the teeth of mammals for here the palaeontologist may have vastly more material than we have supposed. And the most devoted follower of Weismann must feel surprise that the lines of survival are so straight and with so few branches. We cannot fail to notice how largely the palaeontologists are Neo-Lamarckians.

In the emphasis placed on consciousness, will, and effort, this volume is a most valuable and timely contribution. Students of evolution have too generally represented not only vital processes but even life itself as almost or quite purely mechanical, molecular, or chemical. Hence they have either neglected or slurred all its mental aspects. They have sought the living among the dead until they forget what life is and what are its chief characteristics. For supremacy of mind over material, and finally over itself, is the evident goal of evolution. All such purely mechanical or chemical theories, when applied to human progress, necessarily proved misleading or useless.

But when life is defined as "energy directed by sensibility," each of its aspects has received its due emphasis. Well may the author claim that "from this point of view the study of the evolution of mind and its relation to the organic world assumes a new importance."

Now and then the book reminds us of the writings of the Apostle Paul; "in which are some things hard to be understood, which they that are unlearned wrest unto their own destruction." Bathmism we can remember, and its meaning also. But what of Statogenesis, Emphytogenesis, Autobathmogeny, Mnemogenesis, and Cryptopnoÿ? If even Mephistopheles had seen these and sundry other compounds which occur in the volume, he could hardly have found it in his heart to urge an unsuspecting student to "learn words."

Any one who will read this book carefully and thoughtfully cannot fail to have a new, and clearer, and more just, conception of the factors and the process of evolution; and will find his mind continually stimulated to think along new lines.

JOHN M. TYLER.

OSTWALD'S KLASSIKER DER EXAKTEN WISSENSCHAFTEN. A Serial Publication, at Present Embracing More than Eighty Works in Mathematics, Physics, Astronomy, Chemistry, Crystallography, Botany, and Physiology. Edited by Prof. Dr. *Arthur von Oettingen*. Leipsic: Wilhelm Engelmann.

The impression is a widespread one in the popular mind that novelty in science, like novelty in the practical arts, constitutes by the very fact and virtue of its novelty an advance upon the old, supplanting and undoing it. The popular mind,

and with it its reflex popular pedagogy, is in error here, in error principally by its inability to grasp the salient and fundamental features differentiating knowledge, and secondarily by its utter lack of sense for the exigencies of historical and cosmical development—a joint, or rather disjoint, mental condition which leads people lower in the scale of intelligence (say our school-boards) to welcome revisions of the multiplication-table with the same unfeigned delight that the biologist does modifications of Dr. Weismann's theory of heredity. The sciences exhibit varied degrees of *a priority* and formal rigor ranging from arithmetic to psychology, their development has not been contemporaneous, and consequently they are not all at the same stage of perfection. In some we can hope for but little more than new and ingenious presentations, while in others we may expect at any day astounding revelations. We must distinguish between the two classes of knowledge. In the former it is not likely that the same pitch of excellence will again be attained, that we shall ever again in these departments reach the same naturalness and power of thought or the same beauty of exposition—for the sufficient reason that genius will never again apply itself to these departments with equal fervor. The very necessity of such application is wanting, for a truth once discovered remains a truth forever, and is not in need of rediscovery. Such is one of the considerations which in certain branches of knowledge, and under certain restrictions, turns our glance to the past.

But there is another. In this decadent age, with its tendency to intellectual democracy, when every Tom, Dick, and Harry may yield to the unholy impulse to mutilate science, the prime necessity in the spirit which shapes research is a sane conservatism. Not a conservatism which cleaves slavishly to old ideals and methods, which apotheosises old models and stifles the impulses of originality, but a conservatism which ever keeps before the student's mind the marks of high achievement and lofty standards, and holds to his ears the memory-ring of true genius. We are concerned here merely with the plea, which all history confirms, that it is not given to every man and age to reach Olympian heights in their performances, but that some are preferred before others. That aggregation of the cosmic elements which went to make a Michael Angelo, a Kepler, a Shakespeare, or a Kant, is not compacted by the Divine Artificer or *Zeitgeist* in every age of the world's history, though it may be in the making to-day or to-morrow. Inevitably, therefore, and as it were by the very eccentricities of the universe, by the very conditions of intellectual evolution, we are led back to the Golden Ages of Science, Art, or Literature whenever we would seek our highest inspiration and culture.

Some such objects as these, at least on the æsthetical and theoretic side, it is the purpose of Ostwald's Series of Scientific Classics to promote. The series itself is, in its department, one of the most important and deserving enterprises which have been undertaken in recent years. It derives its name from its original editor, Dr. Ostwald, who, on the assumption of that post by Dr. Arthur von Oettingen, likewise an indefatigable scholar, has not ceased his collaboration, but still con-

tinues to enrich the series by selections, translations, and special editorial work. Having originated with a man who, as his recent utterances show, is keenly alive to the stupendous practical import of science, the philosophical, æsthetical, and purely historical ends which the series may primarily seem designed to satisfy, are extended in their significance so as to embrace broad practical aspects of the scientist's culture.

We shall now address ourselves to the contents of the series, beginning with mathematics, and taking up first the Calculus of Variations. It will be profitable here to quote, on the advantages of historical scientific study, the words of Robert Woodhouse, a Cambridge mathematician, the original pioneer in this department, who, in his *Treatise on Isoperimetrical Problems*, published in 1810, after mentioning the stimulus afforded to the student's curiosity and attention by a combination of historical and systematic researches, says:

"But other advantages, besides that of an excited attention, may accrue to "the student from the present plan. He will have an opportunity of observing "how a calculus, from simple beginnings, by easy steps, and seemingly the slight-"est improvements, is advanced to perfection; his curiosity, too, may be stimu-"lated to an examination of the works of the contemporaries of Newton; works "once read and celebrated: yet the writings of the Bernoullis are not antiquated "from loss of beauty, nor deserve neglect, either from obscurity, or clumsiness of "calculation, or shallowness of research. Their processes, indeed, are occasion-"ally somewhat long, and want the trim form of modern solution. They are not, "however, therefore the less adapted to the student, *who is solicitous for just and "full views of science*, rather than for neat novelties and mere store of results. In-"deed, *the authors who write near the beginnings of science are, in general, the most "instructive; they take the reader more along with them, show him the real difficul-"ties, and, which is the main point, teach him the subject, the way by which they "themselves learned it.*"[1]

For this study, and precisely on the subject Woodhouse had in mind, we have in numbers 46 and 47 of Ostwald's Series abundant material. The initial isoperimetrical problems of the Bernoullis are given, the *Methodus inveniendi* of Euler, the two papers of Lagrange, and the two of Legendre and Jacobi. Wholly apart from its scientific importance, there is scarcely a chapter in the history of research that can compare with that of the Calculus for Variations in its intensely human interest. The challenges and strife of the Bernoullis, ending in a bitter feud between the two brothers, the magnanimous generosity of Euler, at that time prince of European mathematicians, who withheld the publication of certain researches till the young Lagrange should publish his, that the latter might not be robbed of "one iota of the rightful fame" due to him for his exquisite solution—all combine to make this period of mathematical history entrancingly interesting. Euler's letter

[1] Italics are ours.

is a model of the scientific attitude. "Your analytical solution of the isoperimetrical problem," he writes to the boy who was thenceforth to share his laurels, "leaves "nothing to be desired in this department of inquiry, and I am delighted beyond "measure that it has been your lot to carry to the highest pitch of perfection a "theory which I have been almost the only one to cultivate from its inception."

Or take another incident. Of the numerous problems which John Bernoulli showered upon the mathematical world in the latter part of the seventeenth century, and which were generally supposed to have been aimed at his brother James, the most famous and the one fraught with the greatest significance for science, was that of the brachistocrone, or the curve of quickest descent. It was answered by Leibnitz, Newton, De l'Hospital, and by James Bernoulli, the latter of whom retorted by a counter-challenge involving a more general problem, and ended by adding that since it was unjust that any one should go unrecompensed for labor on behalf of another and to the detriment of his own affairs, a gentlemen for whom James would vouch pledged himself to give his brother meet praise and fifty ducats besides, provided the latter would furnish a solution of the problem within three months and publish the same within a year. The time-limit John did not take advantage of, but published his solution immediately, saying that "instead of three months it had only taken him three minutes to penetrate the whole mystery." But in one point he had erred. James, to the terror of his brother, increased his wagers in geometrical proportion, and when John ultimately refused to revise his solution on the plea that his time was much better occupied in making new discoveries, gave the crowning retort-courteous in the reply "that if in *three minutes* he had solved the whole mystery, surely *six minutes* more would not much diminish the number of his discoveries." The wrangling of the two brothers continued till the death of James. It had its dark sides, but from its very passion was unusually fruitful for science. We may add that the view of John's unfairness taken by English historians is not wholly accepted by Cantor. Not all the material of the Bernoulli feud is given in the two *Classics* under consideration, but only the initial programmata: the rest is devoted to the modern developments mentioned.

We have also to mention in mathematics the two *Treatises on Spherical Trigonometry* (No. 73) by Euler, which are fundamental in their department. The didactic works of Euler are available to-day as text-books; and, notably in trigonometry, little has been added to the science since his time. His diffuseness is scarce a fault, and it is a significant comment on the methods of discovery that, though many of his demonstrations lack the boasted modern rigor, yet the theorems themselves have generally withstood all assault. On the other hand, the naturalness and lucidity of his explanations might well be readopted in modern instruction. Euler traversed like a conqueror the entire domain of mathematics, transforming and augmenting it at every step. Creator and systematiser, he left everywhere his giant impress. With him, therefore, and particularly in our days of specialisation, intercourse is quickening and chastening.

The other mathematicians represented in the Series are Gauss, Steiner, Jacobi, Abel, Bravais, Laplace, Dirichlet, Charles Ivory, Rosenhain, and Göpel.

We come now to Physics. The first works to claim our attention are: (1) the *Dialogues* of Galileo, in three small volumes (Nos. 11, 24, and 25),[1] admirably translated by Dr. Oettingen, and (2) Huygens's *Treatise on Light*, translated by E. Lommel. The *Dialogues* of Galileo rank as one of the loftiest achievements of the human intellect. They are as perfect in their literary form as they are momentous in their contents, and mark the real beginning of modern science. "They did not," says Lagrange,[2] "procure for Galileo, during his lifetime, the celebrity of his discoveries in the heavens, but to-day they constitute the solidest and realest portion of his transcendent glory. The discovery of the satellites of Jupiter, of the phases of Venus, of the spots of the sun, etc., required but telescopes and assiduity; but extraordinary genius was necessary to disentangle the laws of nature from phenomena which philosophers had always had before their eyes, but whose explanation constantly eluded their efforts." We can grasp Galileo's gigantic performance only by transplanting ourselves to the time in which he lived, by contemplating its absolute intellectual dependence on authority, and by recollecting that he worked almost entirely without instruments. One is struck by his unfailing common sense and insistence on practical points of view, his grace and lucidity of presentation, his simplicity and directness (a point in which he is the direct opposite of Kepler), and by his skilful manipulation of the cumbersome mathematical methods of his time. The inspiration to be derived from these volumes is surpassed only by the insight which they afford into the workings of the archetypal inquiring mind. In this their psychological value they stand without a peer.

Huygens is the second brightest star in the scientific firmament of the sixteenth century. He continued and supplemented with equal genius the work of Galileo, and founded in his *Horologium Oscillatorium* the second parallel development of mechanical ideas which ended in the modern doctrine of energy. He is represented in Ostwald's Series by his famous *Traité de la Lnmiere*, which laid the founeations of the modern undulatory theory of light and which shows at their best the brilliant qualities of his mind. So powerful was the thrall of Newton's genius—even on its mightiest side it deadened the mathematical development of England during a whole century—that under the shadow of the corpuscular theory Huygens's ideas, despite their simplicity, remained undeveloped for fully three generations. The historical significance of the *Treatise* goes without saying; its disciplinary value is equally high. The masterly exposition of the facts and law of double refraction in Chapter V., says Lommel, is instructionally superior to that of the best of modern text-books. The *Horologium Oscillatorium* is missing from the series, but it is hoped the deficiency will soon be supplied.

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[1] The prices of the volumes of the series vary according to the size. Full catalogues may be obtained by addressing W. Engelmann, Verlagsbuchhandlung, Leipsic, Germany.

[2] *Mécanique Analytique*, Vol. I., p. 237, Collected Works, Paris, 1888.

Notable, also, are the *New Magdeburg Experiments* of Otto von Guericke (No. 59), with their quaint drawings, their ponderous and costly equipments (the Bürgermeister spent 20,000 thalers on his apparatus and received as honorarium for his published work only a few free copies), and lastly with their delightful glimpses into the industrial life of the seventeenth century. The third book only of the work is published and contains the experiments on atmospheric pressure substantially as they are given to-day in the elementary school-books.

In No. 57 we have Fahrenheit, Réaumur, and Celsius's papers on *Thermometry*. It is curious to note that the mark 100° was originally placed by Celsius at the freezing point, and 0° at the boiling point.

Lambert's *Photometry* takes up three volumes (Nos. 31, 32, 33). Lambert was a foremost member of that brilliant band of talented men which made the eighteenth century a classical period in science. His versatility is remarkable, and as he was almost entirely self-taught and worked the fields of knowledge after his own sturdy fashion, he is both original and instructive, but at the same time diffuse. He was concerned mostly with general points of view and negligent in his experiments. His entire apparatus while constructing his *Photometry* (which is a pioneer-work in its branch) consisted of three little mirrors, two lenses, a pair of glass plates, and a prism. He persisted in using these instruments even in Berlin, where the best apparatus stood at his disposal, and his skill in the manipulation of his tools is remarkable. The treatise on *Photometry* is largely antiquated, yet the charm of its originality, its solid nucleus of truth, still render it a readable work. "Delivered to-day," says the editor, E. Anding, "it would, despite its diffuseness, specialisation, and repetitions, form an excellent lecture-course in photometric methods." Lambert's character and heart are highly lauded by his contemporaries, and it is said that his fine countenance gave Lavater the first suggestion and stimulus to his physiognomical studies.

An extremely important number is that devoted to the researches on the *Expansive Law of Gases* (No. 44), and containing the papers of Gay-Lussac, Dalton, Dulong, Petit, Rudberg, Magnus, and Regnault. This succession of researches, comprised within the modest compass of 200 pages, is intimately connected with the enunciation of the notion of absolute temperature, and constitutes by the vicissitudes of its development one of the most instructive chapters in the history of science.

Number 63 is devoted to the first researches in Electromagnetism and contains Oersted's brief account of his discovery of the deflexion of a magnetic needle by an electric current, as also an abstract of Seebeck's lectures on the Magnetism of the Galvanic Circuit.

The extraordinary work of Sadi Carnot, *Réflexions sur la puissance motrice du feu*, etc., forms No. 37. Carnot died at the early age of thirty-six (at the same age as Hertz), and his work, though containing the germs of much that was necessary to the formulation of the principle of the conservation of energy, lay almost

unnoticed for a quarter of a century. If we could interpret Carnot's ideas by the right intellectual environment we should be justified in denominating him the discoverer of the important principle known as the first law of thermodynamics. It is certain that his methods led to its discovery and that his work contains substantially the material now formulated in the second law. Carnot's results were known to Helmholtz, whose treatise on the Conservation of Force, with Helmholtz's own notes, edited in 1889, forms the first issue of Ostwald's *Classics*.

Finally, we have in Physics and Astronomy the Spectrum Analysis of Kirchhoff and Bunsen, Gauss's researches on Terrestrial Magnetism and on Forces Acting Inversely as the Square of the Distances, Bessel on the Length of the Second's Pendulum, Neumann on the Mathematical Theory of Induced Electric Currents, Kant on the Theory of the Heavens, Coulomb, Galvani, Hittorf and Seebeck on Electricity and Magnetism, Lavoisier and Laplace on Heat, and so on. In Botany and Physiology but few numbers have as yet appeared. They are essays by Saussure, Pasteur, Kölreuter, Sprengel, Knight, Weber, Ludwig, Becher, Rahn, and Ernst Brücke.

The department of Chemistry alone remains. As might be expected, it is richly represented. The *Dissertation on Fire and Water* (No. 58), by Carl Wilhelm Scheele, the Swedish chemist, written in 1777, remains to-day a marvel of simplicity. A person of common education may read the little book and repeat its experiments with the instruments and ideas which every-day life affords. Scheele, in Ostwald's opinion, possessed the distinctive qualifications of the chemist in their highest development, his experimental skill and powers of inference having never before or since been reached. No. 3 gives the treatises of Dalton and Wollaston on the Atomic Theory. The papers of Dalton are interesting as showing how with inexact analysis and experiments Dalton's thought yet compassed and enunciated so important a principle as the atomic hypothesis. We have here also the first table of atomic weights and the enunciation of Dalton's important theory of the constitution of bodies, and his law of constant and multiple proportions. The paper of Wollaston supplements Dalton's work, and gives experiments that for facility and cogency may be regarded to-day as the best experimental demonstrations of Dalton's laws. It is perhaps unknown to the majority of students that Wollaston was the first who attempted to draw up a more exact picture of the nature of chemical combination by the spatial disposition of atoms.

The speculative researches of Avogadro and Ampère on the foundations of the molecular theory are given in No. 8, the researches of Berthollet on the laws of affinity in No. 74, and the famous investigations of Berthollet's pupil, Gay-Lussac, on iodine in No. 4. Gay-Lussac's paper is accounted the most perfect and exhaustive original investigation of a single chemical element that exists. The discovery of a new element has never been exploited with such thoroughness as in this monograph of the great French chemist. The series also contains the treatises of

Meyer and Mendelejeff, and dissertations by Liebig, Bunsen, Pasteur, Berzelius, Davy, etc.

In the case of many of the older investigators, the editors of the Series have reproduced only what they deemed important. The Series is not, therefore, in all cases a *full* reprint of the scientific classics. It might have been desirable, further, to print the texts of the originals along with the German translations. Although probably not warranted from a commercial point of view, this step would have made the Series international in its character and usefulness. Altogether, we cannot close without words of high commendation for the undertaking, nor without expressing the hope that its range of usefulness will be extensive and its fruits beneficent.

THOMAS J. MCCORMACK.

VORLESUNGEN UEBER GESCHICHTE DER MATHEMATIK. By *Moritz Cantor*. Leipsic: B. G. Teubner. 1894–1896. Price, Vol. I., 22 Marks; Vol. II., 24 Marks; Vol. III., Two Installments, 12 Marks.

It would be impossible to do justice to this monumental work within the brief limits of a book review, even if the task were not rendered supererogatory by the high standing of the work and the acknowledged authority of its author. Cantor's *Lectures on the History of Mathematics* are the work of a man who has unswervingly devoted a life-time to this single task, who thirty-three years ago was well known for his important contributions to this subject, and who can now in the second edition of the first volume of his great work point with pride to the impulse and awakened interest which his endeavors have aroused in the historical studies of his science. He has had many predecessors, each of whom has distinguished himself in certain branches and by certain excellences—Montucla who excelled in lucidity, elegance, and popularity; Libri who seems to have united in an eminent degree all the qualities necessary to the makeup of a writer of a universal mathematical history, but whose work extends only to the period preceding Galileo in Italy; Hankel, whose contributions to the history of early mathematics are marked by much acumen; and several others. Nevertheless, it may safely be said that profundity, accuracy, and extensiveness of treatment have never before in any history of mathematics been so thoroughly and intimately united as in the three volumes constituting these *Lectures* of Moritz Cantor. The first volume embraces the period from earliest antiquity to the year 1200 A. D. and is now in its second edition, thoroughly revised and brought down to date (1894). The second volume embraces the time from 1200 to 1668 A. D. The third and last volume will comprise the time from 1668 to 1759, concluding with the first epoch-making papers of Lagrange in the Proceedings of the Turin Academy. The first two installments only of this third volume have appeared (1894–1896), the third is still in preparation.

In the Introduction to Volume I., which contains 883 pages with a chart of ancient numerical characters, we have some brief philosophical considerations concerning the psychological origin of mathematical operations and the invention